

PATENT ABSTRACTS OF JAPAN

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H03H 9/64

(21)Application number : 10-253597

(71)Applicant : TOYO COMMUN EQUIP CO LTD

(22)Date of filing : 08.09.1998

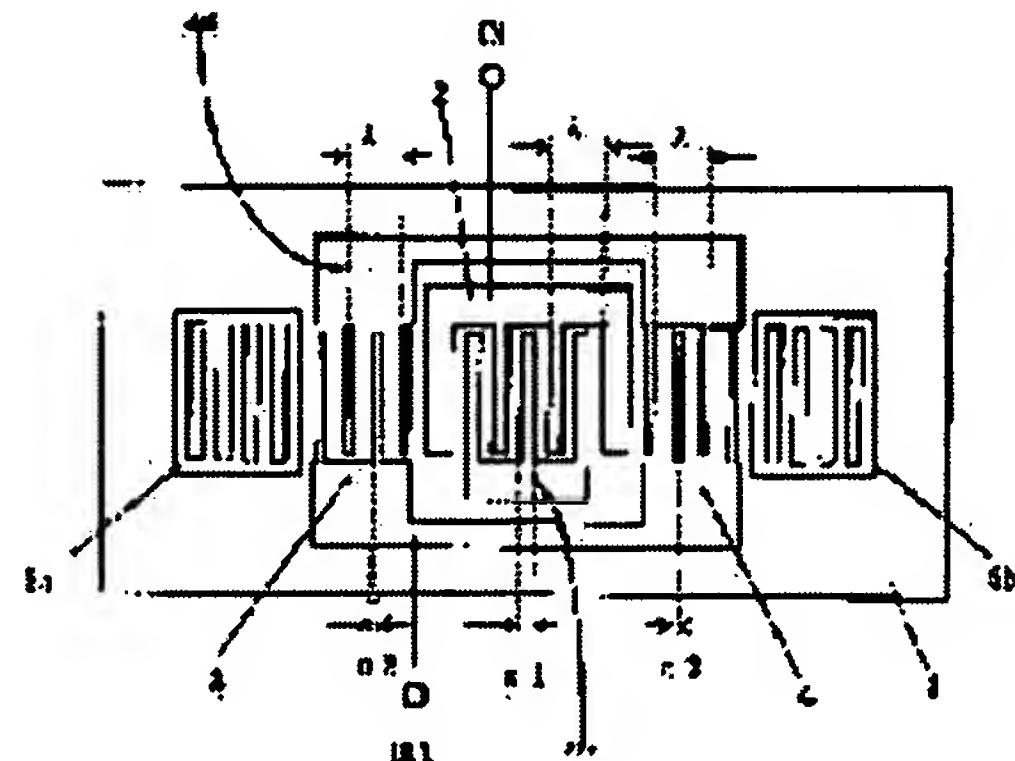
(72)Inventor : OGAWA YUJI

(54) CASCADE CONNECTING DOUBLE MODE SAW FILTER

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain excellent attenuation in a preventing area on a high frequency side in the neighborhood of a pass band by arranging IDT electrodes and grating reflectors along the propagating direction of a surface wave on a piezoelectric substrate and differentiating the exciting frequency of the IDT electrode on an inputting side and that of the IDT electrode on an outputting side.

SOLUTION: Three IDT electrodes 2 to 4 are closely arranged along the propagating direction of the surface wave on the main surface of the piezoelectric substrate 1 and the grating reflectors 5a and 5b are arranged on both sides of these. The electrodes 2 to 4 are formed of a pair of interdigital electrodes with plural electrode fingers respectively inserting each other, one interdigital electrode of the electrode 2 is connected with an input terminal IN and the other interdigital electrode is grounded. On the other hand, respectively one interdigital electrodes of the electrodes 3, 4 are connected with each other and connected to an output terminal OUT and the other interdigital electrodes are connected with each other and grounded in this structure. Then, the exciting frequency of the IDT electrode on the inputting side and that of the IDT electrode on the outputting side are made different from each other.



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CLAIMS

[Claim(s)]

[Claim 1] The vertical joint dual mode SAW filter characterized by changing the exciting frequency of an input-side IDT electrode, and the exciting frequency of an output side IDT electrode in the vertical joint dual mode SAW filter which arranges and constituted the grating reflector along the propagation direction of a surface wave at the both sides of two or more IDT electrodes and this IDT electrode on the piezo-electric substrate.

[Claim 2] The vertical joint dual mode SAW filter according to claim 1 characterized by changing electrode finger line pulse duty factor η_1' of an input-side IDT electrode, and line pulse duty factor η_2' of an output side IDT electrode.

[Claim 3] the electrode finger of an input-side IDT electrode -- a logarithm -- N_1 and a line pulse duty factor -- η_1' -- carrying out -- the electrode finger of an output side IDT electrode -- the ratio of η_1' and η_2' in the case of $N_1 > N_2$, when a logarithm is made to N_2 and a line pulse duty factor is made into η_2' In the case of $0.2 < \eta_2'/\eta_1' < 1 - N_1 < N_2$ Claim 1 characterized by being referred to as $0.2 < \eta_1'/\eta_2' < 1$, or vertical joint dual mode SAW filter given in two.

[Claim 4] The vertical joint dual mode SAW filter according to claim 1 characterized by changing the electrode period λ_1 of an input-side IDT electrode, and the electrode period λ_2 of an output side IDT electrode.

[Claim 5] the electrode finger of an input-side IDT electrode -- a logarithm -- N_1 and an electrode period -- λ_1 -- carrying out -- the electrode finger of an output side IDT electrode -- the ratio of λ_1 and λ_2 in the case of

N1>N2, when a logarithm is set to N2 and an electrode period is set to lambda 2
In the case of $0.960 < \lambda_2 / \lambda_1 < 1.000$ - $N_1 < N_2$ Claim 1 characterized by
being referred to as $0.960 < \lambda_1 / \lambda_2 < 1.000$, or vertical joint dual mode
SAW filter given in four.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] Especially this invention relates to the vertical joint dual mode SAW filter which has improved the inhibition zone magnitude of attenuation by the side of the high region near the passband about a vertical joint dual mode SAW filter.

[0002]

[Description of the Prior Art] In recent years, especially many SAW devices to a cellular phone etc. are used from having the description which was used widely and was [nature / high performance, small, / mass production] excellent in the communication link field. Drawing 7 is the typical top view of the electrode pattern in which the configuration of the conventional primary 3rd [-] length joint dual

mode SAW filter (a dual mode SAW filter is called hereafter) is shown, and it arranges Reflectors 15a and 15b in these both sides while it carries out contiguity arrangement of the three IDT electrodes 12, 13, and 14 along the propagation direction of a surface wave on the principal plane of the piezo-electric substrate 11. The IDT electrodes 12, 13, and 14 are constituted by the tandem type electrode of the couple which has two or more electrode fingers put mutually in between, respectively, they are the IDT electrodes 12, while going away, connect a form electrode to an input terminal IN, and ground the tandem type electrode of another side. On the other hand, it is the IDT electrodes 13 and 14, while going away, the tandem type electrode of another side is connected mutually, and a form electrode grounds it while connecting mutually and connecting with an output terminal OUT.

[0003] The actuation of a dual mode SAW filter shown in drawing 7 Two or more surface waves excited with the IDT electrodes 12, 13, and 14 as everyone knows Reflector 15a, Since it is shut up between 15b, an acoustic turnover is carried out among the IDT electrodes 12, 13, and 14 and two vertical resonance modes, the primary order [3rd], are excited by stress as a result, it operates as a dual mode SAW filter using these two modes by giving suitable termination. In addition, the pass band width of this dual mode SAW filter of being decided by the delta frequency of primary resonance mode and the 3rd resonance mode is well known.

[0004] Drawing 8 shows the filtering property of the dual mode SAW filter of the two-step cascade connection shown in drawing 7 . a piezo-electric substrate -- the 36 degreeY cut X propagation LiTaO₃ -- using -- the electrode of the input IDT electrode 12 -- 20.5 pairs of logarithms N1 the electrode of output electrodes 13 and 14 -- a logarithm N2 -- respectively -- 11.5 pairs and grating 15a -- 250 and electrode layer thickness of an aluminum alloy are set to 6% λ (wavelength of the surface wave by which λ is excited) for the number of 15b, respectively. The pitch of said electrode can be set up so that the center frequency of a filter may be set to 900MHz, and 4% of fractional bandwidths and

a broadband band pass filter can be obtained.

[0005]

[Problem(s) to be Solved by the Invention] However, center frequency with a pass band width of 1dB is set to f_0 so that clearly from the filtering property of drawing 8 . The magnitude of attenuation of frequency-domain $f_0^{**}(45^{**}12.5)$ MHz of a dual mode SAW filter As opposed to about 40dB being obtained in $f_0-(45^{**}12.5)$ MHz by the side of low frequency In the frequency domain A of $f_0+(45^{**}12.5)$ MHz by the side of a RF, only about 20dB was obtained but there was a problem that the specification (25dB or more) required of the latest digital cellular phone could not be satisfied. It is made in order that this invention may solve the above-mentioned problem, and while being a broadband, it aims at offering the dual mode SAW filter which has improved the inhibition zone magnitude of attenuation by the side of the RF near [above-mentioned] the passband.

[0006]

[Means for Solving the Problem] Invention of the vertical joint dual mode SAW applied to this invention in order to attain the above-mentioned object according to claim 1 is a vertical joint dual mode SAW filter characterized by changing the exciting frequency of an input-side IDT electrode, and the exciting frequency of an output side IDT electrode in the vertical joint dual mode SAW filter which arranges and constituted the grating reflector along the propagation direction of a surface wave at the both sides of two or more IDT electrodes and this IDT electrode on the piezo-electric substrate. Invention according to claim 2 is a vertical joint dual mode SAW filter according to claim 1 characterized by changing electrode finger line pulse duty factor η_1' of an input-side IDT electrode, and line pulse duty factor η_2' of an output side IDT electrode. invention according to claim 3 -- the electrode finger of an input-side IDT electrode -- a logarithm -- N_1 and a line pulse duty factor -- η_1' -- carrying out -- the electrode finger of an output side IDT electrode -- the ratio of η_1' and η_2' in the case of $N_1 > N_2$, when a logarithm is made to N_2 and a line pulse duty

factor is made into η_2' In the case of $0.2 < \eta_2'/\eta_1' < 1 - N_1 < N_2$ They are claim 1 characterized by being referred to as $0.2 < \eta_1'/\eta_2' < 1$, or a vertical joint dual mode SAW filter given in two. Invention according to claim 4 is a vertical joint dual mode SAW filter according to claim 1 characterized by changing the electrode period λ_1 of an input-side IDT electrode, and the electrode period λ_2 of an output side IDT electrode. invention according to claim 5 -- the electrode finger of an input-side IDT electrode -- a logarithm -- N_1 and an electrode period -- λ_1 -- carrying out -- the electrode finger of an output side IDT electrode -- the ratio of λ_1 and λ_2 in the case of $N_1 > N_2$, when a logarithm is set to N_2 and an electrode period is set to λ_2 In the case of $0.960 < \lambda_2/\lambda_1 < 1.000 - N_1 < N_2$ They are claim 1 characterized by being referred to as $0.960 < \lambda_1/\lambda_2 < 1.000$, or a vertical joint dual mode SAW filter given in four.

[0007]

[Embodiment of the Invention] This invention is explained to a detail based on the gestalt of operation shown in the drawing below. the top view showing the configuration of the dual mode SAW filter which drawing 1 requires for this invention -- it is -- the principal plane top of the piezo-electric substrate 1 -- the propagation direction of a surface wave -- meeting -- three IDT electrodes 2 and 3 -- while carrying out 4 contiguity arrangement, the grating reflectors 5a and 5b are arranged in these both sides. The IDT electrodes 2, 3, and 4 are constituted by the tandem type electrode of the couple which has two or more electrode fingers put mutually in between, respectively, they are the IDT electrodes 2, while going away, connect a form electrode to an input terminal IN, and ground the tandem type electrode of another side. While being the IDT electrodes 3 and 4, while going away, connecting the form electrode of each other on the other hand and connecting with an output terminal OUT, the tandem type electrode of another side is made into the structure which connects mutually and is grounded.

[0008] The description of this invention is to set up more broadly than the electrode digit η_2 of the IDT electrodes 3 and 4 the electrode digit η_1 of the

IDT electrode 2 while making almost the same the electrode period of the IDT electrodes 2, 3, and 4. drawing 1 -- the electrode of the IDT electrode 2 -- a logarithm N1 -- the electrode of the IDT electrodes 3 and 4 -- it is the set-up example.

[0009] the electrode of a normal mold IDT electrode -- if N and its electrode period are set to lambda and an scaling frequency is set to omega (here $\omega_0 = 2\pi f_0 / \lambda = (\omega - \omega_0) / \omega_0$, $2\pi f_0$ and V rate of a surface wave) for a logarithm -- the frequency characteristics of an IDT electrode -- $\sin(N\pi\omega)/\sin(\pi\omega)$

it comes out and expresses -- having -- an attenuation pole -- every $1/N$ -- appearing -- the bandwidth -- a logarithm -- it is known that it is in inverse proportion to N. The frequency characteristics of this IDT electrode repeated periodically are hereafter called transversal property. The transversal property of the I/O IDT electrodes 2-4 appears, and, as for the frequency characteristics outside the passband of a dual mode SAW filter, the periodic attenuation pole by the transversal property appears in an inhibition zone. Among these, if it can be made in agreement with the frequency domain A of $f_0 + (45 \times 12.5)$ MHz which shows the attenuation pole by the side of the RF of a main lobe to drawing 8 , it will be imagined as that by which the improvement of the magnitude of attenuation of this frequency domain is aimed at.

[0010] the conventional dual mode SAW filter shows to drawing 7 -- as -- the electrode finger of the input IDT electrode 12 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 13 and 14 -- while setting up more mostly than a logarithm N2, it is common to set up the exciting frequency of the I/O IDT electrodes 12, 13, and 14 as it is almost the same. Therefore, the main lobe M1 of the input IDT electrode 12 by the transversal property and the main lobe M2 of the output IDT electrodes 13 and 14 become almost the same [the center frequency of each bandwidth], as shown in drawing 2 (a). however, the electrode of the IDT electrode 12 and the IDT electrodes 13 and 14 -- by setting a logarithm to $N1 > N2$, the bandwidth of each main lobe differs, as shown in

drawing 2 (a). That is, compared with the bandwidth of a main lobe M2, the bandwidth of a main lobe M1 serves as *****. Here, P1 and P2 shall point out the attenuation pole by the side of the RF of main lobes M1 and M2, respectively. Since the passband of a dual mode SAW filter is located in the main lobe M1 of the I/O IDT electrodes 12-14, and M2, the attenuation poles P1 and P2 of a main lobe will appear in the outside of a frequency domain A. Then, various means for controlling the location of the attenuation poles P1 and P2 of a main lobe, and making it in agreement with the frequency domain A which should be improved were examined.

[0011] Consequently, the above-mentioned frequency domain A found that it was impossible to arrange the attenuation poles P1 and P2 of a main lobe only by changing the exciting frequency of an I/O IDT electrode simply. although this reason is located in the main lobe of the transversal property that the I/O IDT electrodes 12-14 present the passband of a dual mode SAW filter -- the electrode of the input IDT electrode 12 -- a logarithm N1 -- each electrode of the output IDT electrodes 13 and 14 -- since it has set up more mostly than a logarithm N2, it will be formed inside the bandwidth of the main lobe M1 with the narrow bandwidth formed with the input IDT electrode 12.

[0012] The attenuation poles P1 and P2 of a main lobe cannot be made in agreement with a frequency domain A with a means to arrange the main lobe M1 with narrow bandwidth from the main lobe M2 with wide bandwidth to a high frequency side by the above reason as shown in drawing 2 (b). Then, it found out that it was possible to make it in agreement with the frequency domain A where a dual mode SAW filter should improve the attenuation pole P1 which appears in the RF side of a main lobe M1 by arranging the main lobe M1 with narrow bandwidth from the main lobe M2 with wide bandwidth to a low frequency side, as shown in drawing 2 (c).

[0013] First, the case where the exciting frequency of an IDT electrode is changed by changing an electrode pitch is examined. Drawing 3 is the dual mode SAW filter which changed each exciting frequency by setting constant the line

pulse duty factor of the IDT electrodes 6, 7, and 8, and changing mutually the IDT electrode 6, the IDT electrodes 7 and 8, and an electrode finger pitch. Two-step cascade connection of the dual mode SAW filter of drawing 3 is carried out, and the result of having asked for the magnitude of attenuation and electrode period ratio (λ_2/λ_1) relation to a frequency domain A by simulation is shown in drawing 4 . the range of an electrode period ratio (λ_2/λ_1) which the magnitude of attenuation in a frequency domain A can improve, maintaining a passband in the good condition so that clearly from drawing 4 -- the electrode finger of an input electrode -- a logarithm N_1 -- the electrode finger of an output electrode -- case [than a logarithm N_2] more -- 0.96 -- < -- it turned out that it is $\lambda_2/\lambda_1 < 1.000$.

[0014] Based on the above-mentioned result, the 36 degreeY cut X propagation LiTaO₃ is used for a piezo-electric substrate. the electrode finger of the input IDT electrode 6 -- a logarithm N_1 -- the electrode finger of 22.5 pairs and the output IDT electrodes 7 and 8 -- 12.5 pairs of logarithms N_2 , respectively 250 and the electrode layer thickness of an aluminum alloy for the number of the grating reflectors 9a and 9b 6% λ , When the dual mode SAW filter which set as 0.980 the ratios λ_2/λ_1 of the electrode period λ_2 of the output IDT electrodes 7 and 8 which receive input IDT electrode period λ_1 was constituted, it turned out that the magnitude of attenuation can improve about 8dB of the filtering property in the frequency domain of $f_0 + (45^{**} 12.5)$ MHz. However, the differences of the above-mentioned electrode period are very few actually, and the effectiveness may fully be unable to be enjoyed according to the manufacture error by the present photolithography technique.

[0015] Then, we decided to examine a means to change an exciting frequency for IDT the same electrode period. There are an approach of changing the electrode layer thickness of an IDT electrode to the 1st, and a method of changing the line pulse duty factor (line width-of-face/(line width-of-face + tooth-space width of face)) of an IDT electrode finger to the 2nd. Although it is necessary to control to accuracy the IDT electrodes 2 and 3 which adjoin across

1-2-micrometer space on the same piezo-electric substrate, and the thickness of 4 by the former, with a current technique, manufacture variation is not so practical greatly as well as a production process becoming complicated. Then, how to change mutually the line width of face eta 1 of the IDT electrode 2 and the line width of face eta 2 of the IDT electrodes 3 and 4 as shown in drawing 1 was examined as a means to change an exciting frequency, without changing the electrode period of an I/O IDT electrode. Since it is the same electrode period, the ratio of the line width of face eta1 and eta2 is equal to the ratio of each line pulse duty factor eta1' and eta2'.

[0016] IDT -- an electrode -- two -- three -- four -- an electrode -- a period -- the same -- carrying out -- an input -- IDT -- an electrode -- two -- a line -- a pulse duty factor -- eta -- one -- ' -- an output -- IDT -- an electrode -- three -- four -- a line -- a pulse duty factor -- eta -- two -- ' -- mutual -- differing -- making -- things -- each -- an exciting frequency -- changing -- the dual mode -- an SAW filter -- having constituted -- an example -- drawing 1 -- it is . Drawing 5 is the result of asking for the relation between the magnitude of attenuation and a line pulse duty factor ratio (η_2'/η_1') by simulation in the frequency domain A of the filter which carried out two-step cascade connection of the dual mode SAW filter shown in drawing 1 ($f_0+(45^{**}12.5)$ MHz). the ratio of the line pulse duty factor which the magnitude of attenuation can improve in the frequency domain A in drawing 8 while this had maintained the passband in the good condition -- η_2'/η_1' -- the electrode finger of an input electrode -- a logarithm N_1 -- the electrode finger of an output electrode -- case [than a logarithm N_2] more -- 0.2 -- < -- eta 2 -- '/eta1' -- it is shown that it should set up with <1.

[0017] Drawing 6 is drawing showing the filtering property of the filter constituted based on the above-mentioned examination result. a piezo-electric substrate -- the 36 degreeY cut X propagation LiTaO₃ -- using -- the electrode finger of the input IDT electrode 2 -- 20.5 pairs of logarithms N_1 the electrode finger of the output IDT electrodes 3 and 4 -- a logarithm N_2 -- respectively -- 11.5 pairs and grating reflector 5a -- five -- b -- a number -- 250 -- a ** -- an aluminum alloy -- an

electrode layer -- thickness -- six -- % -- lambda -- an input -- IDT -- an electrode -- a line -- a pulse duty factor -- eta -- one -- ' -- receiving -- an output -- IDT -- an electrode -- a line -- a pulse duty factor -- eta -- two -- ' -- a ratio -- eta -- two -- ' -- / -- eta -- one -- ' -- 0.43 -- having set up -- ** -- the property of a case -- it is . In addition, the electrode finger pitch was set up so that a center of filter frequency might be set to 900MHz.

[0018] It turns out that about 10dB improves compared with the magnitude of attenuation of the conventional dual mode SAW filter which the magnitude of attenuation by the side of the RF near the passband (frequency domain A) indicated to drawing 8 was clear from drawing 6 . The demand of RF filter for cellular phones which needs to make the magnitude of attenuation near the passband steeper than this improvement can fully be filled now.

[0019] explanation of drawing 1 -- the electrode finger of the input IDT electrode 2 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 3 and 4, although the example in the case of [than a logarithm N2] more was taken up conversely, the electrode finger of the input IDT electrode 2 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 3 and 4 -- the case where will change a line pulse duty factor and the magnitude of attenuation in a frequency domain A will be improved if the case of being fewer than a logarithm N2 is examined -- a line pulse duty factor ratio -- 0.2 -- < -- eta1'/eta2' -- <1, then a good thing have been checked.

[0020] moreover -- the example of drawing 5 -- the electrode finger of the input IDT electrode 6 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 7 and 8, although the case more than a logarithm N2 was explained conversely, the electrode finger of the input IDT electrode 6 -- a logarithm N1 -- the electrode finger of the output IDT electrodes 7 and 8 -- if the case of being fewer than a logarithm N2 is examined, for changing an electrode period and improving the magnitude of attenuation of a frequency domain A -- an electrode period ratio -- 0.96 -- < -- lambda1/lambda2<1.000, then a good thing were checked.

[0021] In addition, although the above explanation explained to the primary 3rd [-] length joint dual mode SAW filter which used three IDT electrodes, it is not necessary to say that it can apply if this invention is a dual mode SAW filter which is not limited only to this and has two or more IDT electrodes.

[0022] Furthermore, although explanation of this invention showed above the example which used the 36 degreeY cut X propagation LiTaO₃ to the piezo-electric substrate, this invention is not limited only to this and can be applied to the vertical joint dual mode SAW filter using any piezo-electric substrates. For example, it is not necessary to say that it is applicable also to the piezoelectric material of 45-degreeX cut Z propagation Li₂B₄O₇, ST cut Xtal, the 42 degreeY cut X propagation LiTaO₃, or 64 degreeY cut X propagation LiNbO₃ grade.

[0023]

[Effect of the Invention] Since this invention was constituted as explained above, in a vertical joint dual mode SAW filter, about 10dB of magnitude of attenuation by the side of the RF near the passband can be improved now, and the effectiveness which was excellent when improving the engine performance, if the dual mode SAW filter of this invention is used for RF filters, such as a cellular phone, is expressed.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the top view showing the electrode configuration of the primary 3rd [-] length joint dual mode SAW filter concerning this invention.

[Drawing 2] (a), (b), and (c) are drawings explaining the frequency of a main lobe and the relation of a filter shape which an I/O IDT electrode presents.

[Drawing 3] It is the example of the primary 3rd [-] length joint dual mode SAW filter concerning this invention, and is the top view of the filter which changed and constituted the electrode period.

[Drawing 4] It is drawing showing the relation between the pitch ratio of an IDT electrode, and the magnitude of attenuation by the side of the RF near the passband.

[Drawing 5] It is drawing showing the relation between line pulse duty factor ratio λ_2'/λ_1' and the magnitude of attenuation near the pass band of a dual mode SAW filter.

[Drawing 6] It is the filtering property which asked for the dual mode SAW filter concerning this invention by simulation.

[Drawing 7] It is the top view showing the electrode configuration of the conventional primary 3rd [-] length joint dual mode SAW filter.

[Drawing 8] It is drawing showing the filter shape of the conventional primary 3rd [-] length joint dual mode SAW filter.

[Description of Notations]

1 .. Piezo-electric substrate

3, 4, 6, 7, 8 .. IDT electrode

5a, 5b, 9a, 9b .. Grating reflector

λ_1, λ_2 .. IDT electrode period

η_1, η_2 .. Line width of face

η_1', η_2' .. Line pulse duty factor

M1, M2 .. Main lobe

P1, P2 .. Attenuation by the side of the RF of a main lobe

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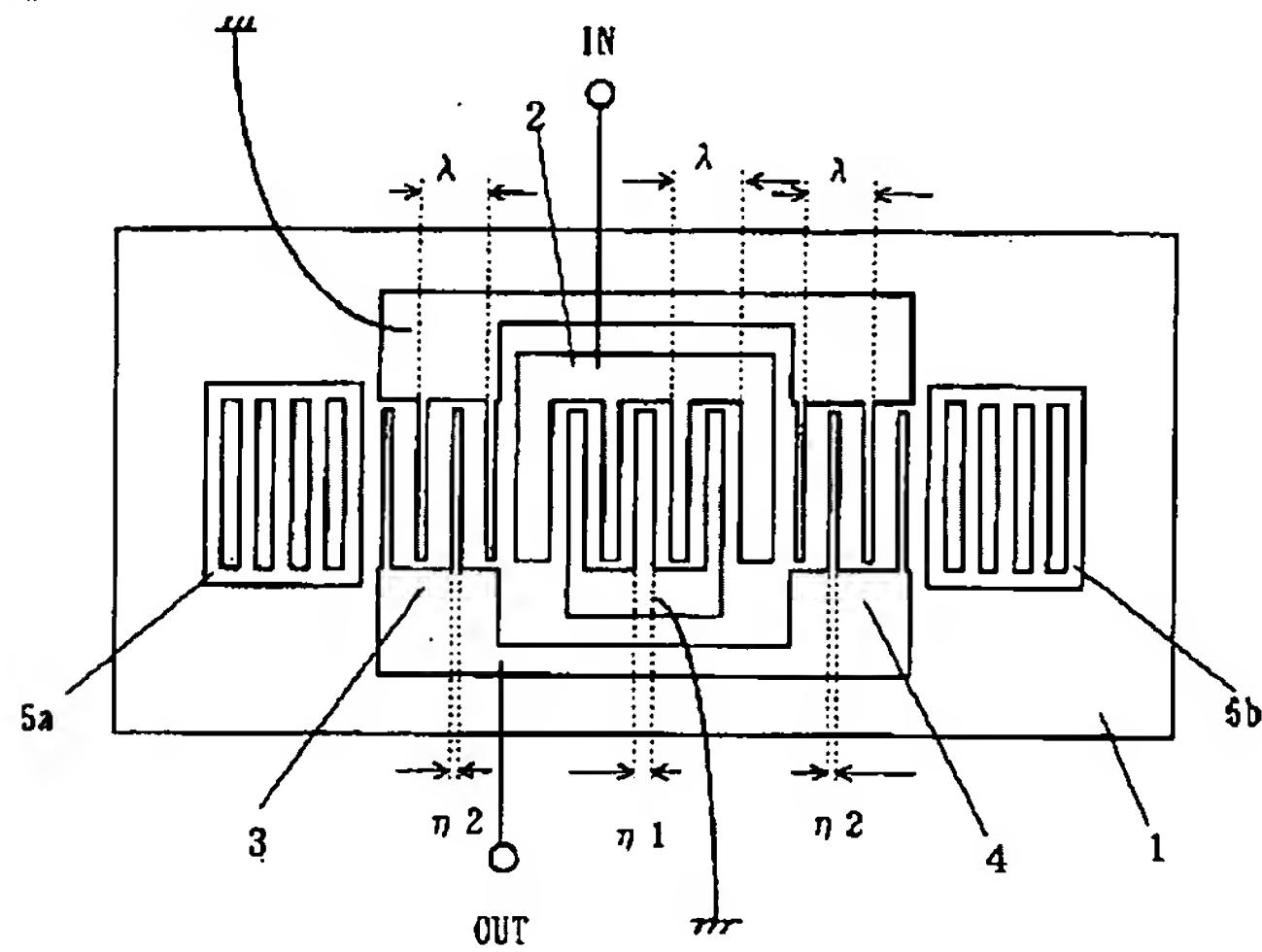
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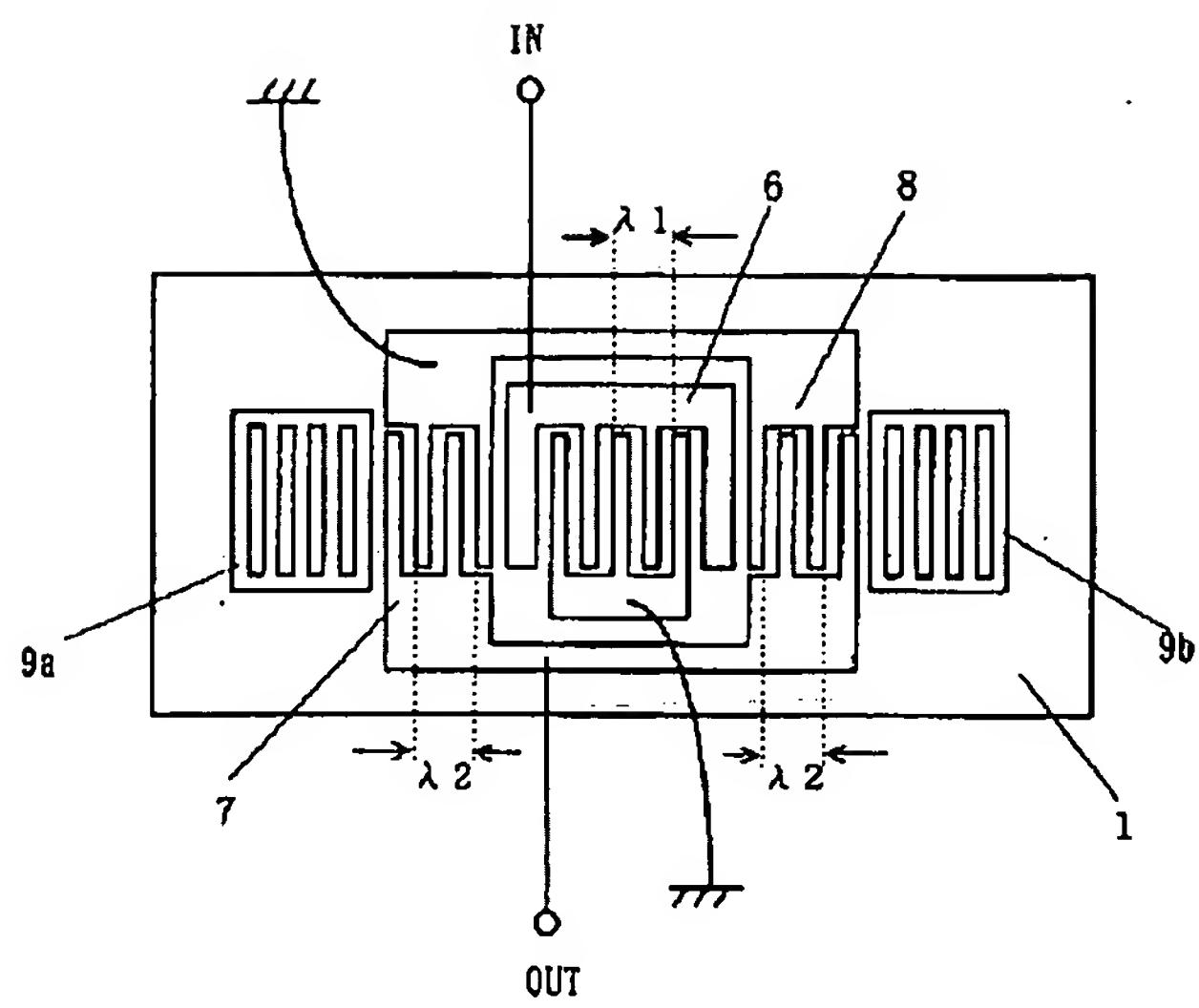
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DRAWINGS

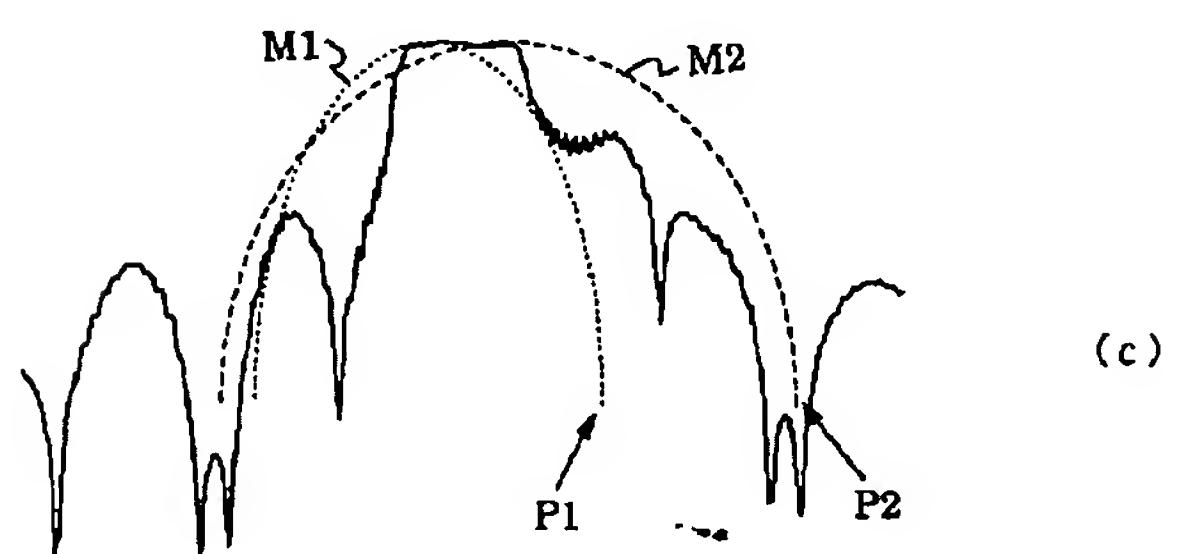
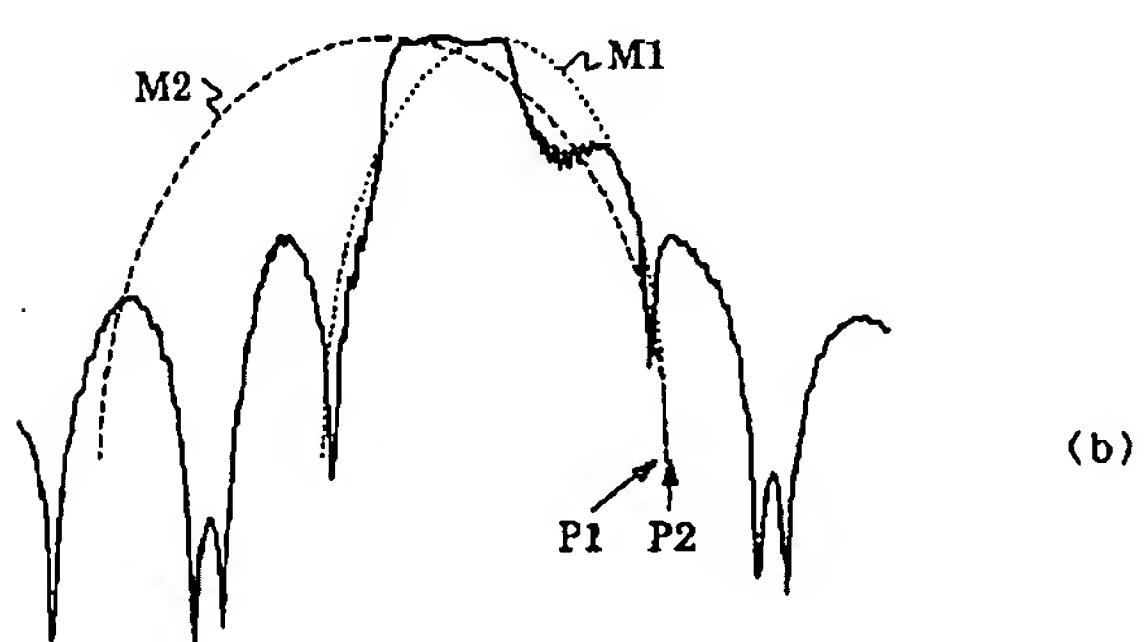
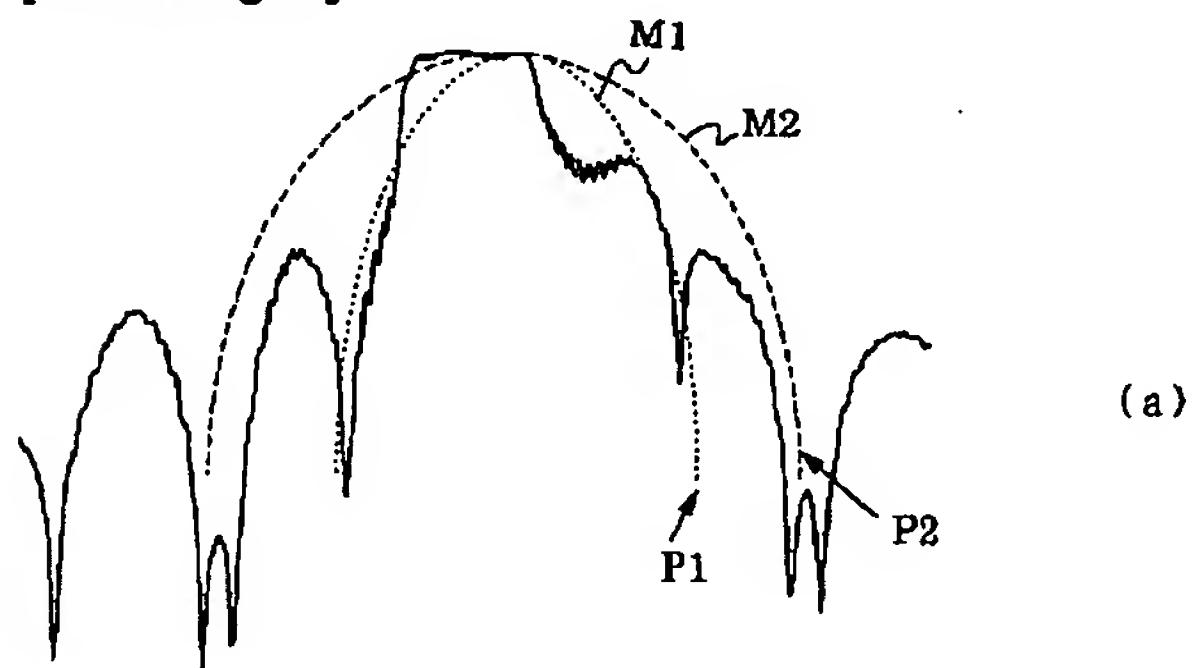
[Drawing 1]



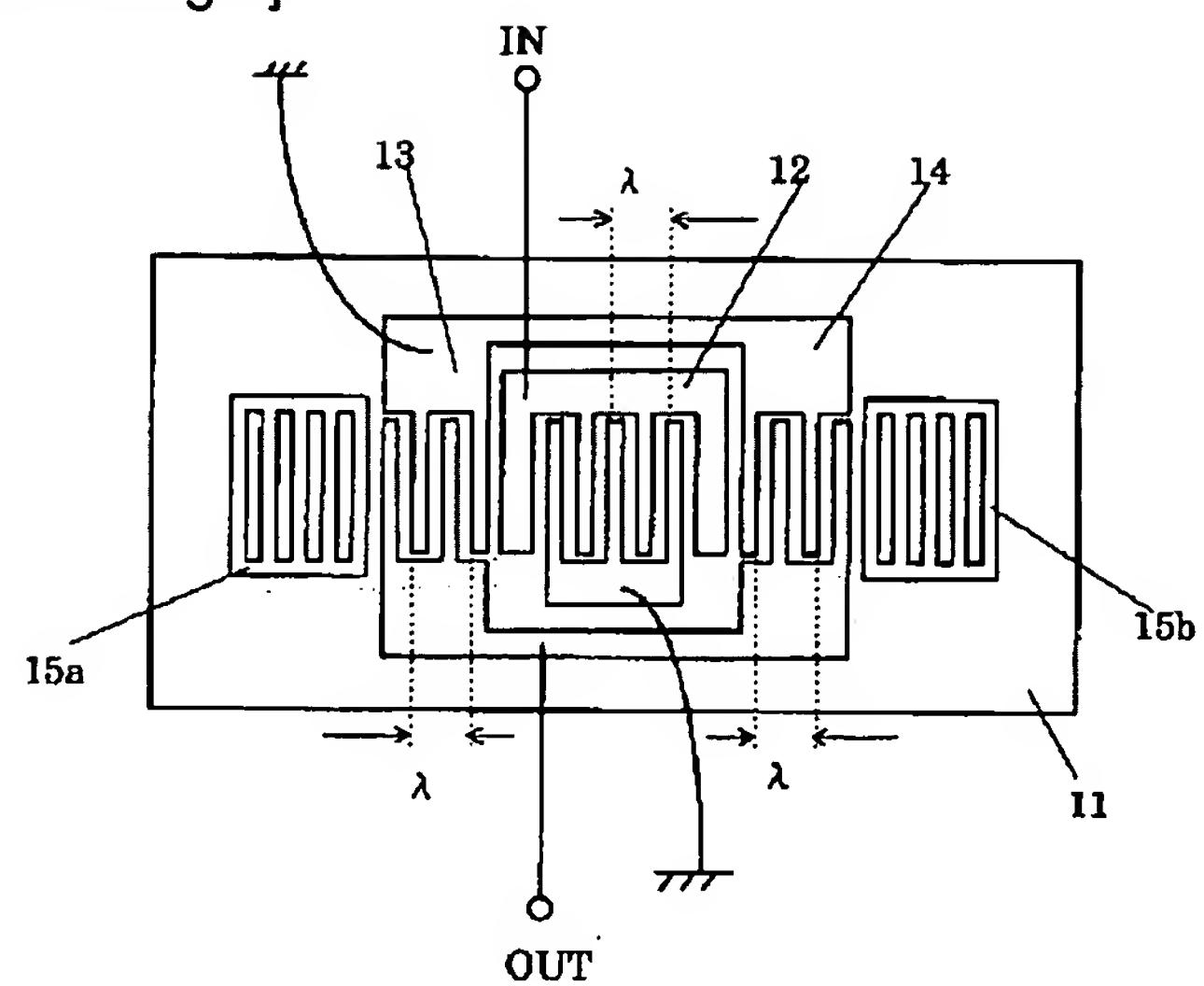
[Drawing 3]



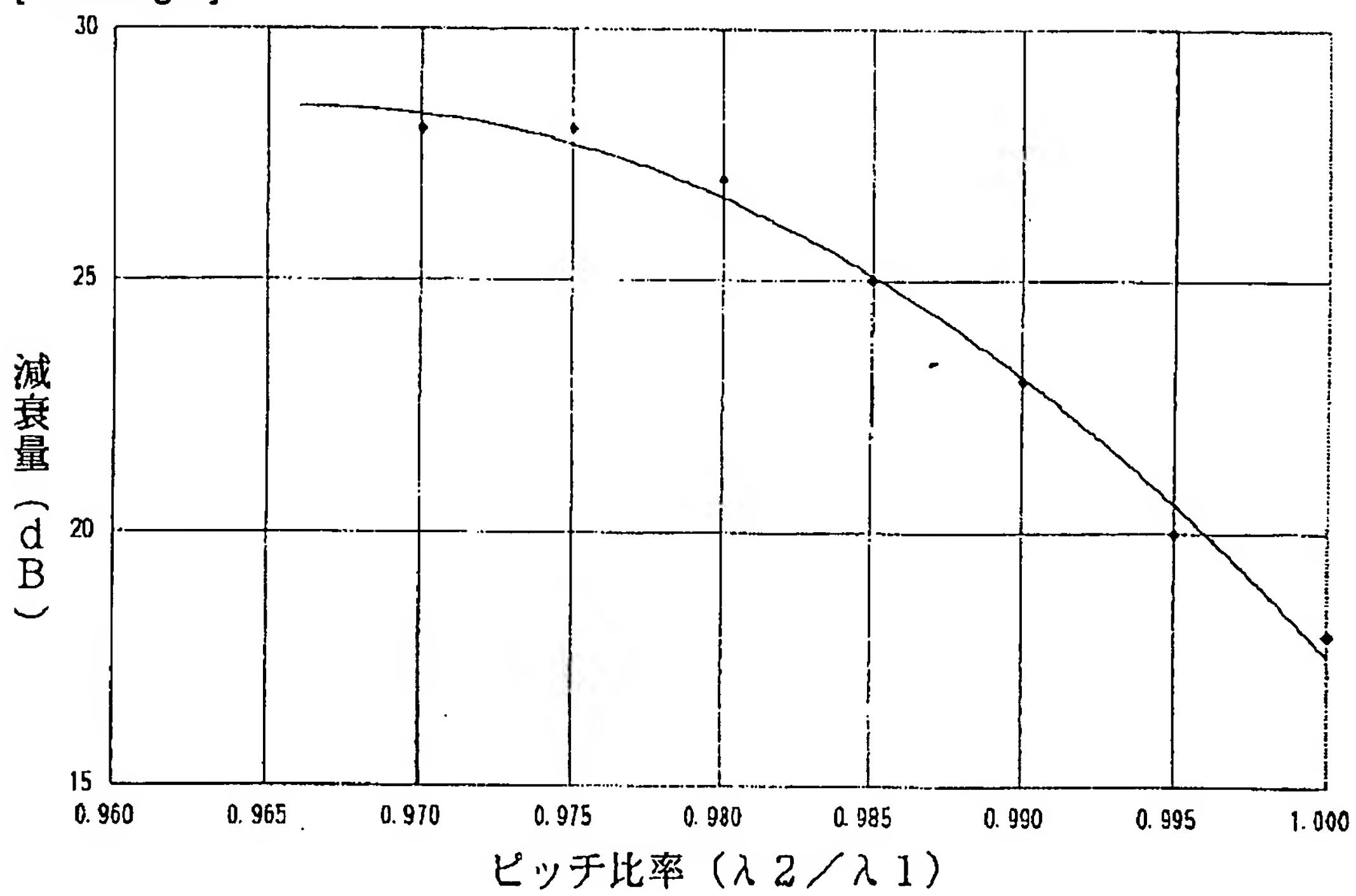
[Drawing 2]



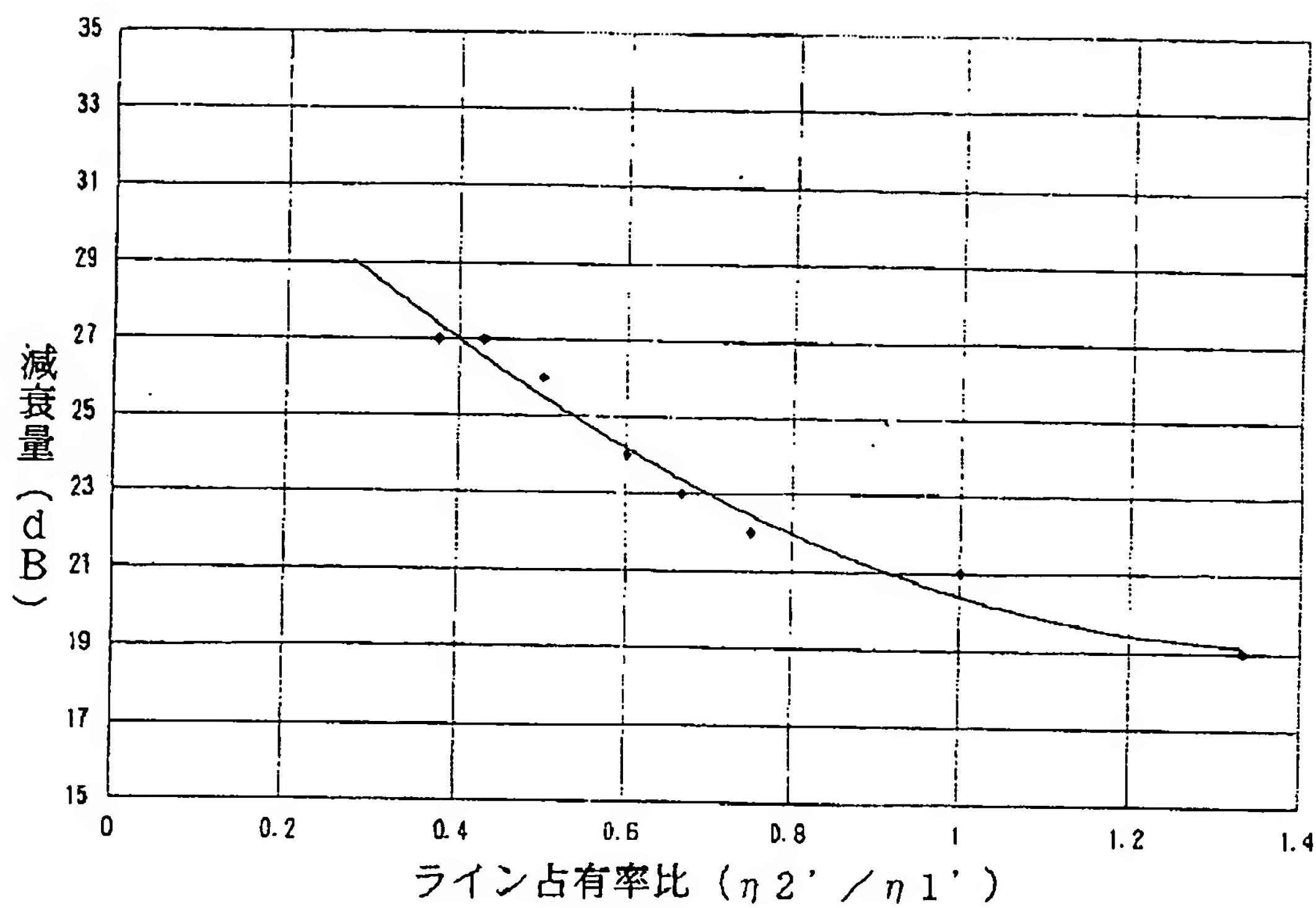
[Drawing 7]



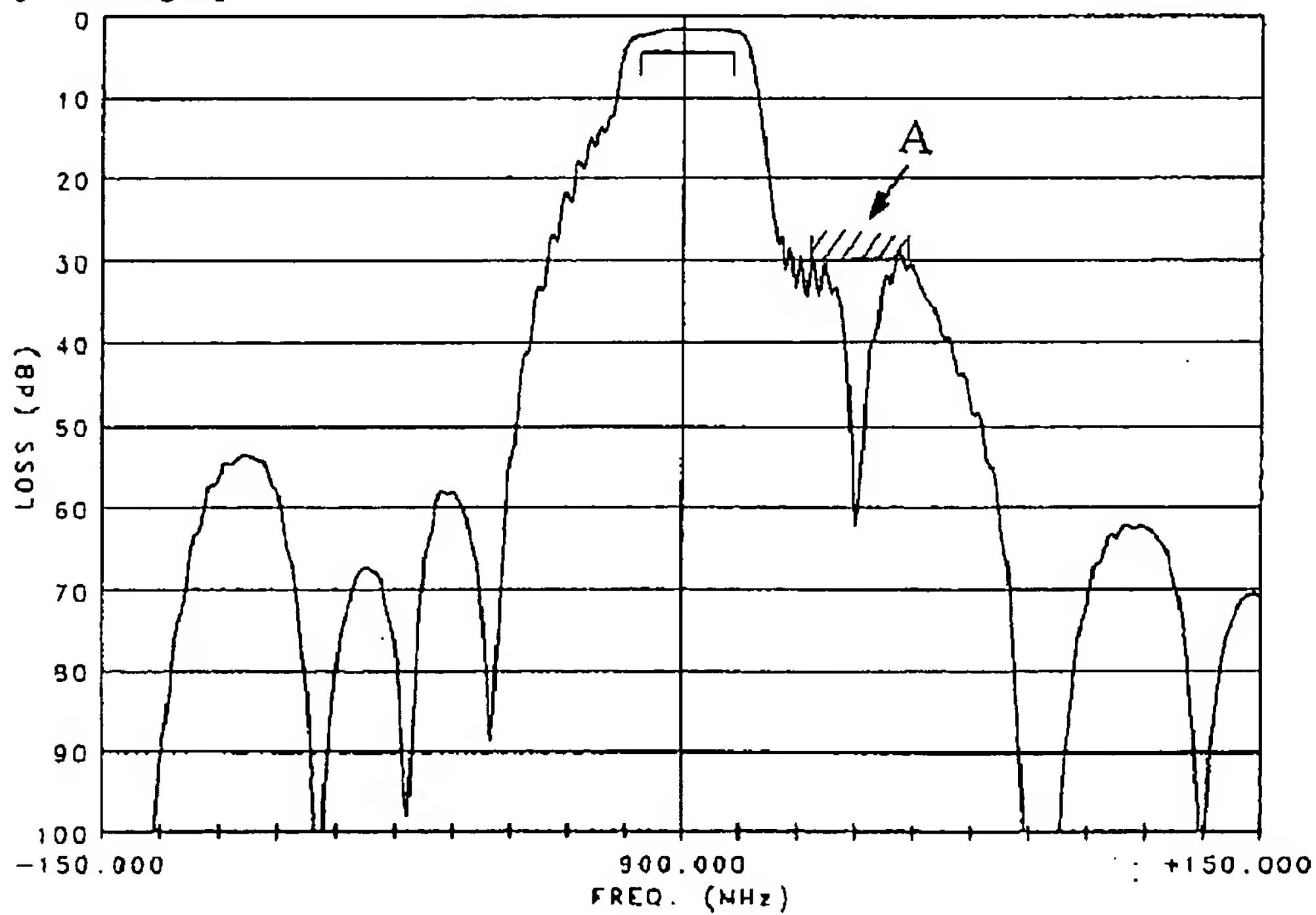
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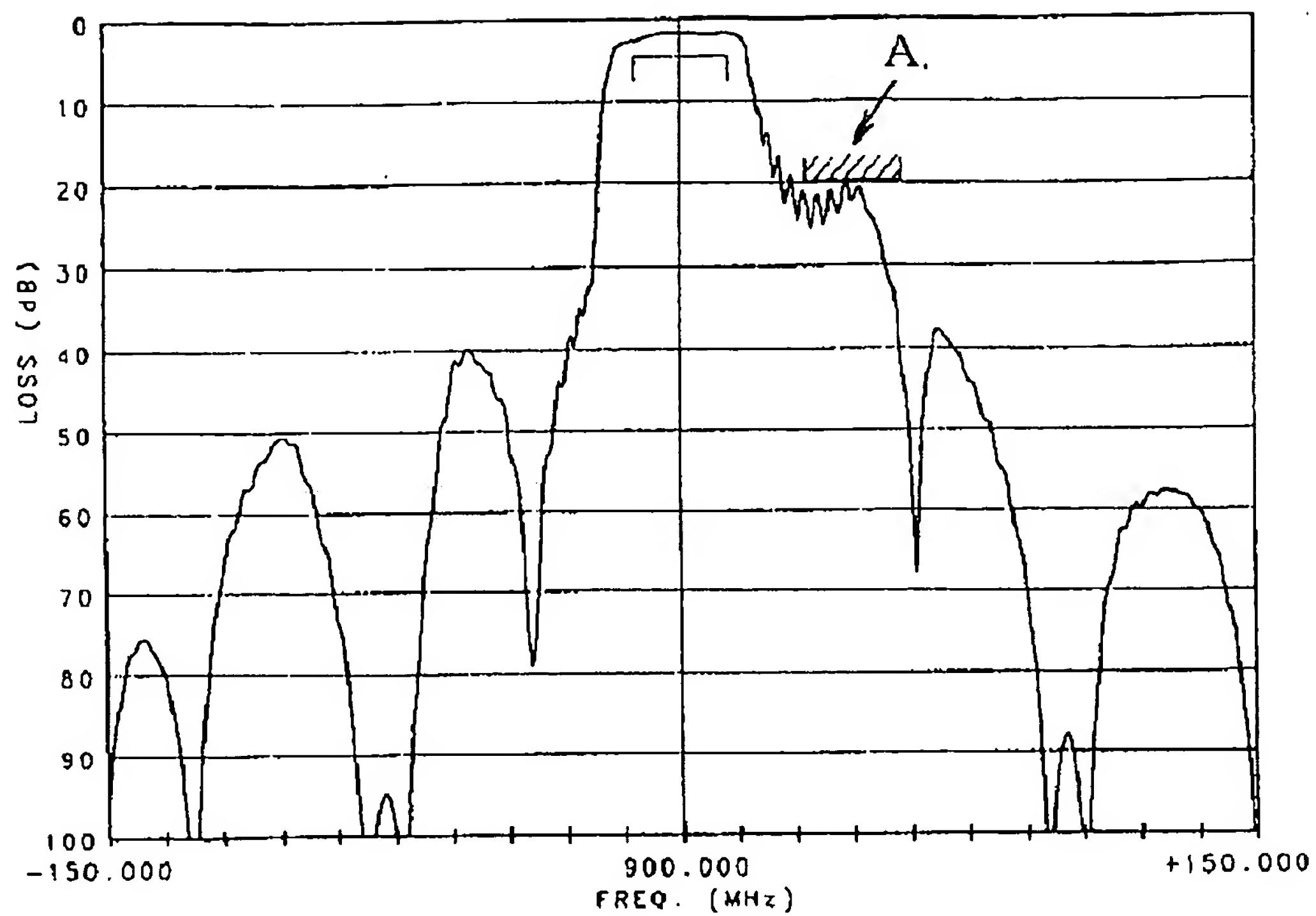
[Drawing 5]



[Drawing 6]



[Drawing 8]



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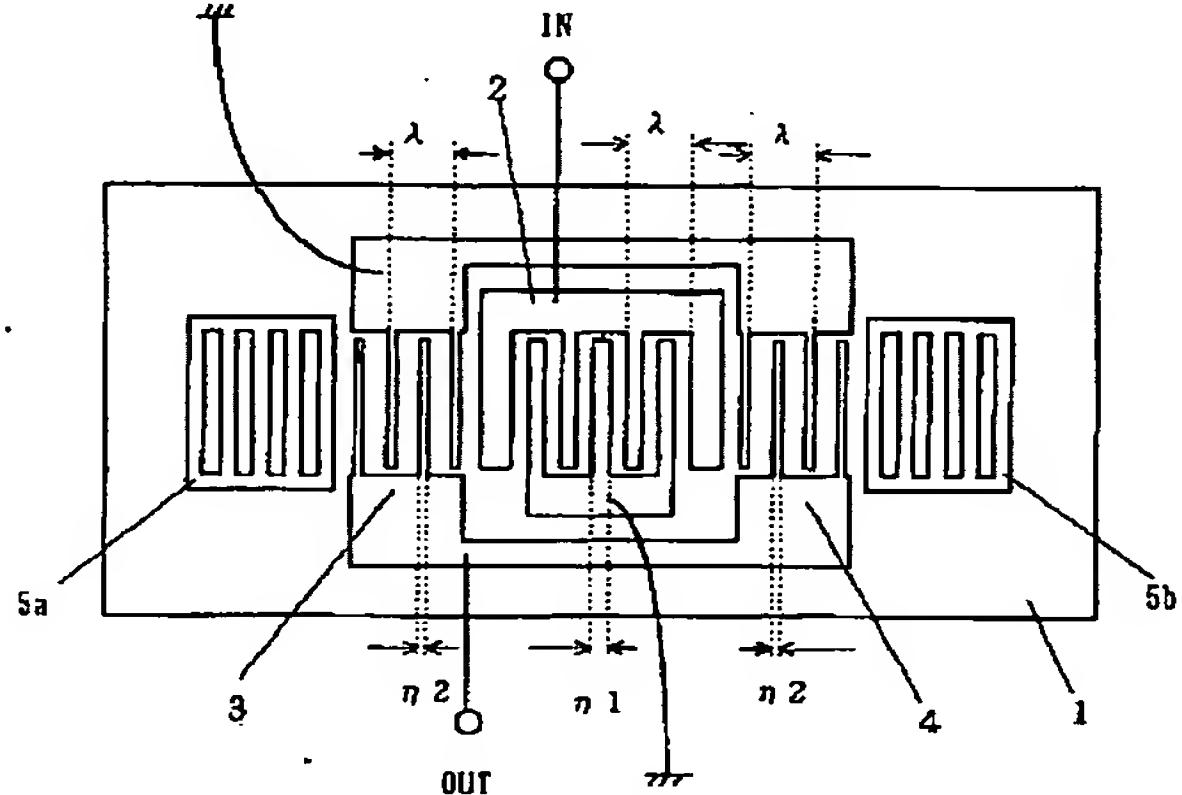
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(54) 【発明の名称】縦結合二重モード SAW フィルタ

(57) 【要約】

【課題】 縦結合二重モード SAW フィルタの通過帯域近傍の高周波側に生じる減衰量の劣化を補償する手段を得る。

【解決手段】 圧電基板上に少なくとも 2 個の IDT 電極と 2 個のグレーティング反射器とを用いて構成した縦結合二重モード SAW フィルタにおいて、入力側 IDT 電極の励振周波数と出力側 IDT 電極の励振周波数を異ならせる。



【特許請求の範囲】

【請求項1】 圧電基板上に表面波の伝搬方向に沿って2個以上のIDT電極と該IDT電極の両側にグレーティング反射器とを配置して構成した縦結合二重モードSAWフィルタにおいて、入力側IDT電極の励振周波数と出力側IDT電極の励振周波数を異ならせることを特徴とする縦結合二重モードSAWフィルタ。

【請求項2】 入力側IDT電極の電極指ライン占有率 η_1' と出力側IDT電極のライン占有率 η_2' を異ならせることを特徴とする請求項1記載の縦結合二重モードSAWフィルタ。

【請求項3】 入力側IDT電極の電極指対数をN1、ライン占有率を η_1' とし、出力側IDT電極の電極指*

N1>N2の場合 0.960< λ_2/λ_1 <1.000

N1<N2の場合 0.960< λ_1/λ_2 <1.000

としたことを特徴とする請求項1あるいは4記載の縦結合二重モードSAWフィルタ。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は縦結合二重モードSAWフィルタに関し、特に通過帯域近傍の高域側の阻止域減衰量を改善した縦結合二重モードSAWフィルタに関する。

【0002】

【従来の技術】近年、SAWデバイスは通信分野で広く利用され、高性能、小型、量産性等の優れた特徴を有することから特に携帯電話等に多く用いられている。図7は従来の1次-3次縦結合二重モードSAWフィルタ

(以下、二重モードSAWフィルタと称す)の構成を示す電極パターンの模式的平面図であって、圧電基板11の主面上に表面波の伝搬方向に沿って3つのIDT電極12、13、14を近接配置すると共に、これらの両側に反射器15a、15bを配設したものである。IDT電極12、13、14はそれぞれ互いに間挿し合う複数本の電極指を有する一対のくし形電極により構成され、IDT電極12の一方のくし形電極は入力端子INに接続し、他方のくし形電極は接地する。一方、IDT電極13、14の一方のくし形電極は互いに連結して出力端子OUTに接続すると共に、他方のくし形電極は互いに連結して接地する。

【0003】図7に示す二重モードSAWフィルタの動作は、周知のように、IDT電極12、13、14によって励起される複数の表面波が反射器15a、15bの間に閉じ込められて、IDT電極12、13、14の間で音響結合し、その結果1次と3次の2つの縦共振モードが強勢に励振されるため、適当な終端を施すことによりこれらの2つのモードを利用した二重モードSAWフィルタとして動作する。なお、該二重モードSAWフィルタの通過帯域幅は1次共振モードと3次共振モードとの周波数差で決まることは周知の通りである。

*対数をN2、ライン占有率を η_2' としたとき、 η_1'

と η_2' との比を

N1>N2の場合 0.2< η_2'/η_1' <1

N1<N2の場合 0.2< η_1'/η_2' <1

とすることを特徴とする請求項1あるいは2記載の縦結合二重モードSAWフィルタ。

【請求項4】 入力側IDT電極の電極周期 λ_1 と出力側IDT電極の電極周期 λ_2 とを異ならせたことを特徴とする請求項1記載の縦結合二重モードSAWフィルタ。

【請求項5】 入力側IDT電極の電極指対数をN1、電極周期を λ_1 とし、出力側IDT電極の電極指対数をN2、電極周期を λ_2 としたとき、 λ_1 と λ_2 との比を

N1>N2の場合 0.960< λ_2/λ_1 <1.000

N1<N2の場合 0.960< λ_1/λ_2 <1.000

【0004】図8は、図7に示す2段縦続接続の二重モードSAWフィルタの濾波特性を示したものであって、圧電基板に36°YカットX伝搬LiTaO₃を用い、入力IDT電極12の電極対数N1を20.5対、出力電極13、14の電極対数N2をそれぞれ11.5対、グレーティング15a、15bの本数をそれぞれ250本、アルミニウム合金の電極膜厚を6%λ(λは励起される表面波の波長)とし、フィルタの中心周波数を900MHzになるように前記電極のピッチを設定したものであり、比帯域4%と広帯域なバンドパスフィルタを得ることができる。

【0005】

【発明が解決しようとする課題】しかしながら、図8の濾波特性から明らかなように、1dBの通過帯域幅の中心周波数を f_0 とし、二重モードSAWフィルタの周波数領域 $f_0 \pm (45 \pm 12.5) \text{MHz}$ の減衰量は、低周波側の $f_0 - (45 \pm 12.5) \text{MHz}$ では40dB程度得られるのに対して、高周波側の $f_0 + (45 \pm 12.5) \text{MHz}$ の周波数領域Aでは20dB程度しか得られず、最近のデジタル携帯電話に要求される仕様(25dB以上)を満足できないという問題があった。本発明は上記問題を解決するためになされたものであって、広帯域であると共に上記通過帯域近傍の高周波側の阻止域減衰量を改善した二重モードSAWフィルタを提供することを目的とする。

【0006】

【課題を解決するための手段】上記目的を達成するため本発明に係る縦結合二重モードSAWの請求項1記載の発明は、圧電基板上に表面波の伝搬方向に沿って2個以上のIDT電極と該IDT電極の両側にグレーティング反射器とを配置して構成した縦結合二重モードSAWフィルタにおいて、入力側IDT電極の励振周波数と出力側IDT電極の励振周波数を異ならせることを特徴とする縦結合二重モードSAWフィルタである。請求項2記載の発明は、入力側IDT電極の電極指ライン占有率

η_1' と出力側IDT電極のライン占有率 η_2' を異ならせたことを特徴とする請求項1記載の縦結合二重モードSAWフィルタである。請求項3記載の発明は、入力側IDT電極の電極指対数をN1、ライン占有率を η_1' とし、出力側IDT電極の電極指対数をN2、ライン占有率を η_2' としたとき、 η_1' と η_2' との比をN1>N2の場合 0.2< η_2' / η_1' <1 N1<N2の場合 0.2< η_1' / η_2' <1

とすることを特徴とする請求項1あるいは2記載の縦結合*

N1>N2の場合 0.960< λ_2 / λ_1 <1.000

N1<N2の場合 0.960< λ_1 / λ_2 <1.000

とすることを特徴とする請求項1あるいは4記載の縦結合二重モードSAWフィルタである。

【0007】

【発明の実施の形態】以下本発明を図面に示した実施の形態に基づいて詳細に説明する。図1は本発明に係る二重モードSAWフィルタの構成を示す平面図であって、圧電基板1の主面上に表面波の伝搬方向に沿って3つのIDT電極2、3、4近接配置すると共に、これらの両側にグレーティング反射器5a、5bを配設する。IDT電極2、3、4はそれぞれ互いに間挿し合う複数本の電極指を有する一対のくし形電極により構成され、IDT電極2の一方のくし形電極は入力端子INに接続し、他方のくし形電極は接地する。一方、IDT電極3、4の一方のくし形電極は互いに連結して出力端子OUTに接続すると共に、他方のくし形電極は互いに連結して接地する構造とする。

【0008】本発明の特徴は、IDT電極2、3、4の電極周期をほぼ同一とすると共に、IDT電極2の電極指幅 η_1 をIDT電極3、4の電極指幅 η_2 より幅広に設定することにある。図1はIDT電極2の電極対数N1をIDT電極3、4の電極対数N2より多く設定した例である。

【0009】正規型IDT電極の電極対数をN、その電極周期を λ 、基準化周波数を Ω ($= (\omega - \omega_0) / \omega_0$ 、ここで $\omega_0 = 2\pi V / \lambda = 2\pi f_0$ 、Vは表面波の速度) とすると、IDT電極の周波数特性は、

$$\sin(N\pi\Omega) / \sin(\pi\Omega)$$

で表され、減衰極は $1/N$ おきに現れ、その帯域幅は対数Nに反比例することが知られている。この周期的に繰り返すIDT電極の周波数特性を以下、トランスバーサル特性という。二重モードSAWフィルタの通過帯域外の周波数特性は、入出力IDT電極2～4のトランスバーサル特性が現れ、阻止域にはそのトランスバーサル特性による周期的な減衰極が現れる。このうちメインロープの高周波側の減衰極を、図8に示す $f_0 + (45 \pm 1.5) \text{ MHz}$ の周波数領域Aに一致させることができれば、該周波数領域の減衰量の改善がはかられるものと推察される。

【0010】従来の二重モードSAWフィルタでは図7

*合二重モードSAWフィルタである。請求項4記載の発明は、入力側IDT電極の電極周期 λ_1 と出力側IDT電極の電極周期 λ_2 を異ならせたことを特徴とする請求項1記載の縦結合二重モードSAWフィルタである。請求項5記載の発明は、入力側IDT電極の電極指対数をN1、電極周期を λ_1 とし、出力側IDT電極の電極指対数をN2、電極周期を λ_2 としたとき、 λ_1 と λ_2 との比を

に示すように入力IDT電極12の電極指対数N1を出力IDT電極13、14の電極指対数N2より多く設定すると共に、入出力IDT電極12、13、14の励振周波数をほぼ同一と設定するのが一般的である。従つて、トランスバーサル特性による入力IDT電極12のメインロープM1、出力IDT電極13、14のメインロープM2は図2(a)に示すように、それぞれの帯域幅の中心周波数はほぼ同一となる。ところが、IDT電極12とIDT電極13、14との電極対数をN1>N2とすることにより、それぞれのメインロープの帯域幅は図2(a)に示すように異なる。つまり、メインロープM2の帯域幅に比べ、メインロープM1の帯域幅は狭窄となる。ここで、P1、P2はそれぞれメインロープM1、M2の高周波側の減衰極を指すものとする。二重モードSAWフィルタの通過帯域は、入出力IDT電極12～14のメインロープM1、M2内に位置するので、メインロープの減衰極P1、P2は周波数領域Aの外側に現れることになる。そこでメインロープの減衰極P1、P2の位置を制御して、改善すべき周波数領域Aに一致させるための手段を種々検討した。

【0011】その結果、入出力IDT電極の励振周波数を単純に異ならせるだけでは、上記の周波数領域Aにメインロープの減衰極P1、P2を配置することは不可能であることが分かった。この理由は、二重モードSAWフィルタの通過帯域は入出力IDT電極12～14が呈するトランスバーサル特性のメインロープ内に位置しているが、入力IDT電極12の電極対数N1を出力IDT電極13、14のそれぞれの電極対数N2より多く設定しているために、入力IDT電極12によって形成される帯域幅の狭いメインロープM1の帯域幅の内側に形成されることになる。

【0012】以上の理由で、図2(b)に示すように帯域幅の狭いメインロープM1を帯域幅の広いメインロープM2より高周波側に配置する手段では周波数領域Aにメインロープの減衰極P1、P2を一致させることができない。そこで、図2(c)に示すように帯域幅の狭いメインロープM1を帯域幅の広いメインロープM2より低周波側に配置することにより、メインロープM1の高周波側に現れる減衰極P1を二重モードSAWフィルタ

の改善すべき周波数領域Aに一致させることができることを見出した。

【0013】まず、IDT電極の励振周波数を電極ピッチを変えることにより変化させた場合を検討する。図3はIDT電極6、7、8のライン占有率を一定として、IDT電極6とIDT電極7、8と電極指ピッチを互いに異ならせることにより、それぞれの励振周波数を変えた二重モードSAWフィルタである。図3の二重モードSAWフィルタを2段継続接続して、周波数領域Aにおける減衰量と電極周期比(λ_2/λ_1)関係をシミュレーションにより求めた結果を図4に示す。図4から明らかなように、通過帯域を良好な状態に維持したまま、周波数領域Aにおける減衰量が改善できる電極周期比(入 λ_2/λ_1)の範囲は、入力電極の電極指対数N1が出力電極の電極指対数N2より多い場合には、 $0.96 < \lambda_2/\lambda_1 < 1.000$ であることが判った。

【0014】上記の結果に基づき、圧電基板に36°YカットX伝搬LiTaO₃を用い、入力IDT電極6の電極指対数N1を22.5対、出力IDT電極7、8の電極指対数N2をそれぞれ12.5対、グレーティング反射器9a、9bの本数を250本、アルミニウム合金の電極膜厚を6% λ 、入力IDT電極周期 λ_1 に対する出力IDT電極7、8の電極周期 λ_2 の比 λ_2/λ_1 を0.980に設定した二重モードSAWフィルタを構成すると、その濾波特性は $f_0 + (45 \pm 12.5)$ MHzの周波数領域で減衰量が約8dB改善できることが分かった。ところが、実際には上記電極周期の差はごく僅かであり、現在のフォトリソグラフィ技術による製造誤差により、その効果を十分に享受することができない場合がある。

【0015】そこで、IDTを同一の電極周期で励振周波数を変える手段を検討することとした。第1にIDT電極の電極膜厚を変化させる方法、第2にIDT電極指のライン占有率(ライン幅/(ライン幅+スペース幅))を変化させる方法がある。前者では、同一の圧電基板上で1~2μmの空間を挟んで隣接するIDT電極2と3、4との膜厚を正確に制御することが必要となるが、製造工程が複雑となるのはもちろん、現在の技術では製造バラツキが大きくあまり実用的ではない。そこで、入出力IDT電極の電極周期を変えずに、励振周波数を変化させる手段として、図1に示すようにIDT電極2のライン幅 η_1 とIDT電極3、4のライン幅 η_2 とを互いに異ならせる方法を検討した。同一電極周期であるためライン幅 η_1 、 η_2 の比はそれぞれのライン占有率 η_1' 、 η_2' の比と等しい。

【0016】IDT電極2、3、4の電極周期を同一にし、入力IDT電極2のライン占有率 η_1' と出力IDT電極3、4のライン占有率 η_2' を互いに異ならせることにより、それぞれの励振周波数を変えて二重モードSAWフィルタを構成した例が図1である。図5は、図

1に示した二重モードSAWフィルタを2段継続接続したフィルタの周波数領域A($f_0 + (45 \pm 12.5)$ MHz)において、その減衰量とライン占有率比(η_2'/η_1')との関係をシミュレーションにより求めた結果である。これは通過帯域を良好な状態に維持したまま、図8における周波数領域Aにおいて減衰量が改善できるライン占有率の比 η_2'/η_1' は、入力電極の電極指対数N1が出力電極の電極指対数N2より多い場合には、 $0.2 < \eta_2'/\eta_1' < 1$ と設定すべきであることを示している。

【0017】図6は上記の検討結果に基づき構成したフィルタの濾波特性を示す図であって、圧電基板に36°YカットX伝搬LiTaO₃を用い、入力IDT電極2の電極指対数N1を20.5対、出力IDT電極3、4の電極指対数N2をそれぞれ11.5対、グレーティング反射器5a、5bの本数を250本、アルミニウム合金の電極膜厚を6% λ 、入力IDT電極のライン占有率 η_1' に対する出力IDT電極のライン占有率 η_2' の比 η_2'/η_1' を0.43に設定した場合の特性である。なお電極指ピッチはフィルタの中心周波数が900MHzになるように設定した。

【0018】図6から明らかなように通過帯域近傍の高周波側(周波数領域A)の減衰量が、図8に示した従来の二重モードSAWフィルタの減衰量に比べて10dB程度改善されていることが分かる。この改善より通過帯域近傍の減衰量を急峻にする必要がある携帯電話用RFフィルタの要求を十分に満たすことができるようになった。

【0019】図1の説明では、入力IDT電極2の電極指対数N1が出力IDT電極3、4の電極指対数N2より多い場合の例を取り上げたが、逆に入力IDT電極2の電極指対数N1が出力IDT電極3、4の電極指対数N2より少ない場合を検討すると、ライン占有率を変えて周波数領域Aにおける減衰量を改善する場合、ライン占有率比は $0.2 < \eta_1'/\eta_2' < 1$ とすればよいことが確認できた。

【0020】また、図5の例では入力IDT電極6の電極指対数N1が出力IDT電極7、8の電極指対数N2より多い場合を説明したが、逆に入力IDT電極6の電極指対数N1が出力IDT電極7、8の電極指対数N2より少ない場合を検討すると、電極周期を変えて周波数領域Aの減衰量を改善するには、電極周期比を $0.96 < \lambda_1/\lambda_2 < 1.000$ とすればよいことを確認した。

【0021】なお、以上の説明では3個のIDT電極を用いた1次-3次継結合二重モードSAWフィルタに説明したが、本発明はこれのみに限定されるものではなく2個以上のIDT電極を持つ二重モードSAWフィルタであれば適用可能であることは云うまでもない。

【0022】さらに、以上本発明の説明で圧電基板に3

6° YカットX伝搬LiTaO₃を用いた例を示したが、本発明はこれのみに限定されるものではなく、どのような圧電基板を用いた縦結合二重モードSAWフィルタにも適用可能である。例えば45° XカットZ伝搬Li₂B₄O₇、STカット水晶、42° YカットX伝搬LiTaO₃あるいは64° YカットX伝搬LiNbO₃等の圧電材料にも適用できることは云うまでもない。

[0 0 2 3]

【発明の効果】本発明は、以上説明したように構成したので、縦結合二重モード SAW フィルタにおいて通過帯域の近傍の高周波側の減衰量を 10 dB 程度改善することができるようになり、本発明の二重モード SAW フィルタを携帯電話等の RF フィルタに用いればその性能を改善する上で優れた効果を表す。

【図面の簡単な説明】

【図1】本発明に係る1次-3次縦結合二重モードSAWフィルタの電極構成を示す平面図である。

【図2】(a)、(b)、(c)は入出力IDT電極の呈するメインロープの周波数とフィルタ特性の関係を説明する図である。

【図3】本発明に係る1次-3次縦結合二重モードSAWフィルタの実施例で、電極周期を変えて構成したフィ

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ルタの平面図である。

【図4】IDT電極のピッチ比と通過帯域近傍の高周波側の減衰量との関係を示す図である。

【図5】 ライン占有率比 λ_2' / λ_1' と二重モードSAWフィルタの通過域近傍の減衰量との関係を示す図である。

【図6】本発明に係る二重モードSAWフィルタをシミュレーションにより求めた濾波特性である。

【図7】従来の1次-3次縦結合二重モードSAWフィルタの電極構成を示す平面図である。

【図8】従来の1次-3次縦結合二重モードSAWフィルタのフィルタ特性を示す図である。

【符号の説明】

1.1.1 壓電基板

3、4、6、7、8···IDT電極

5 a, 5 b, 9 a, 9 b · · グ

$\lambda_1, \lambda_2 \dots$ IDT 電

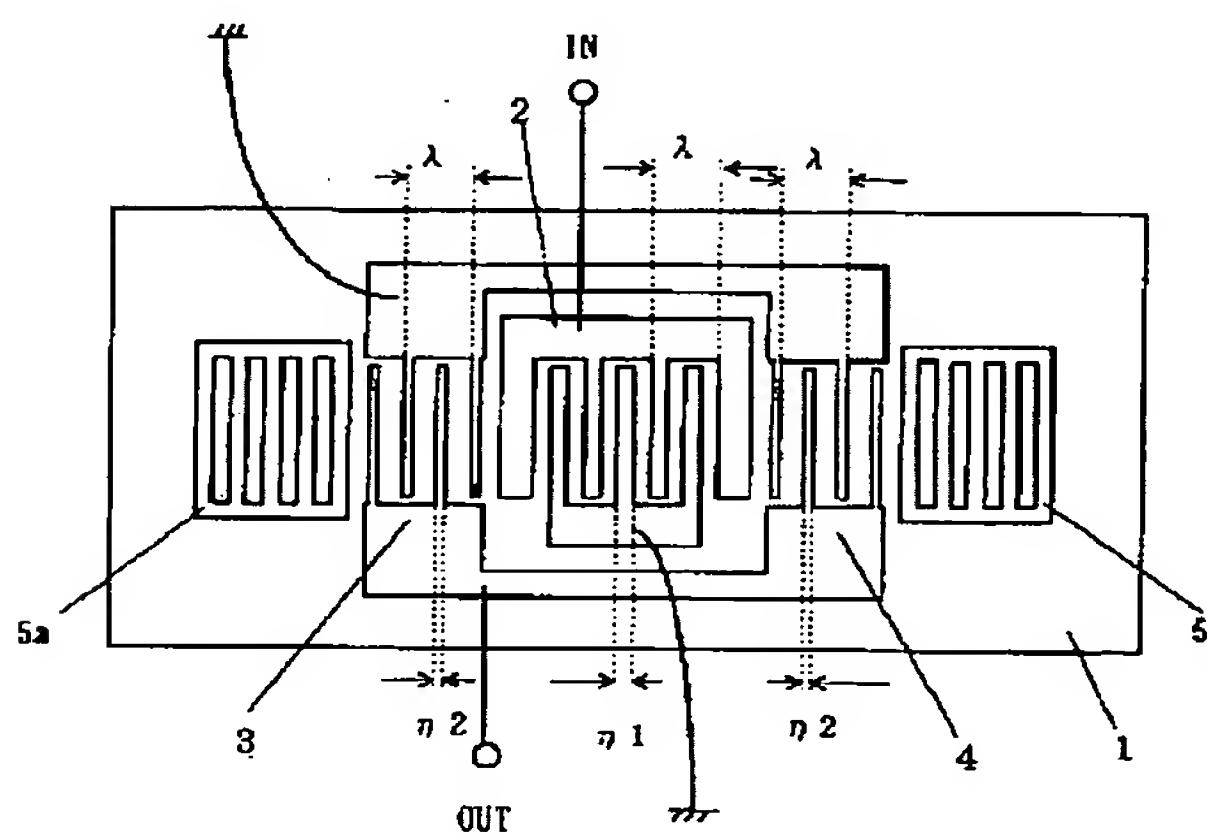
$\eta_1, \eta_2 \dots$ ライン幅

η1'、η2'…ライン占

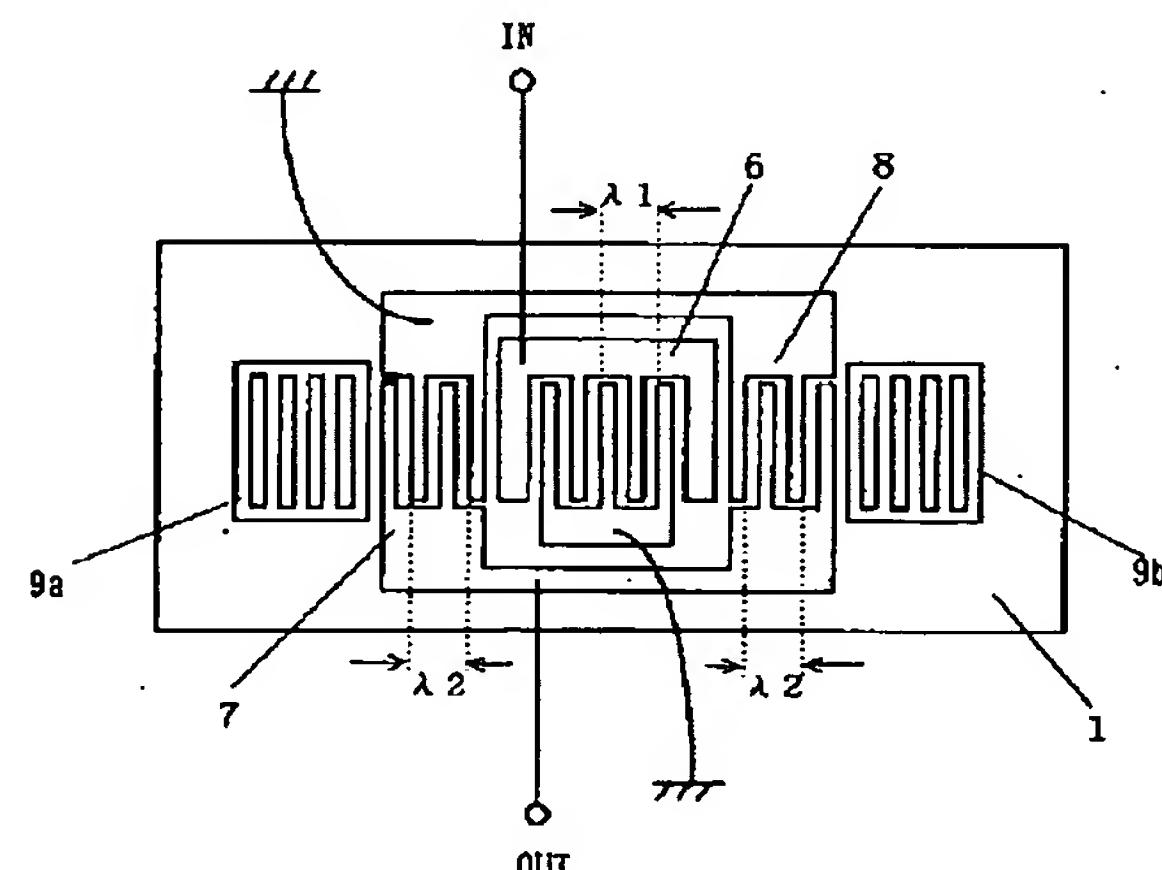
M1、M2・・・メインロープ

P1、P2…メインロープの高周波側の減衰

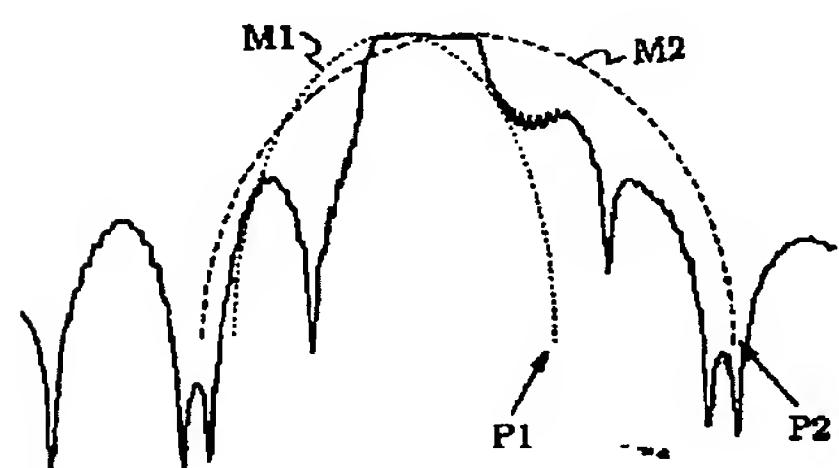
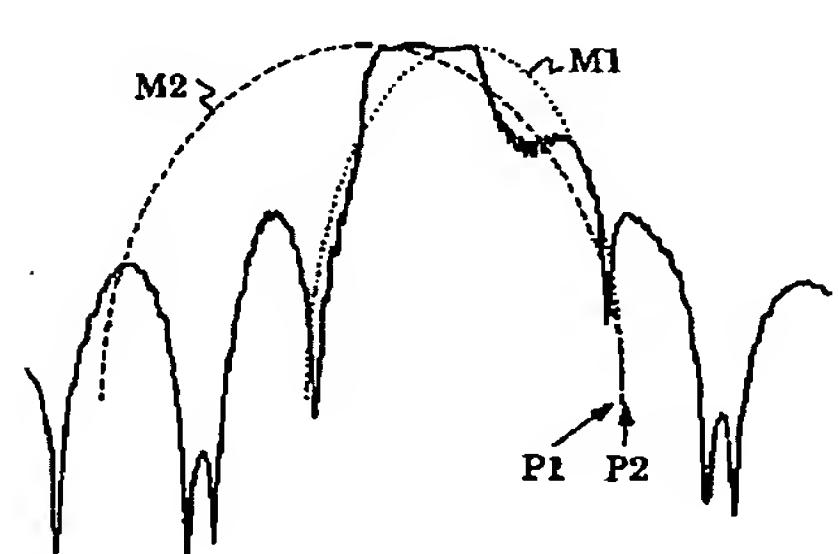
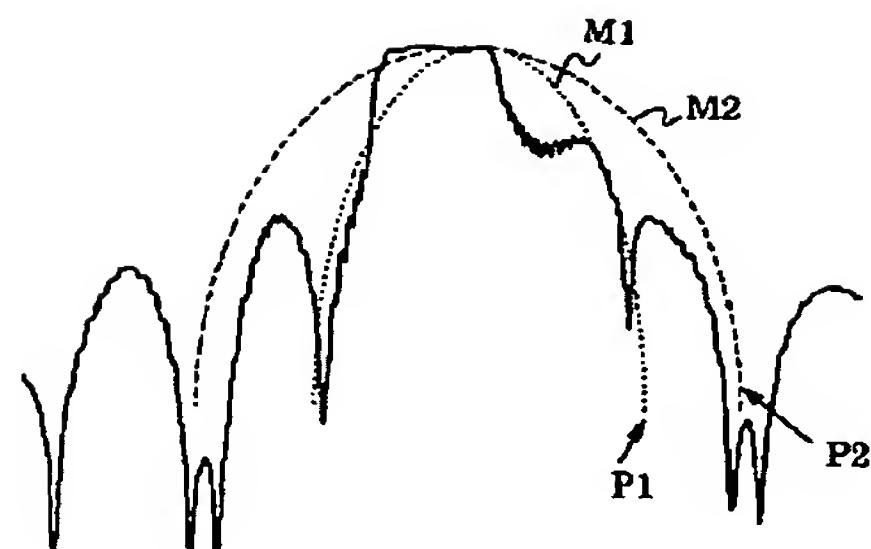
[图 1]



[図3]



【図2】

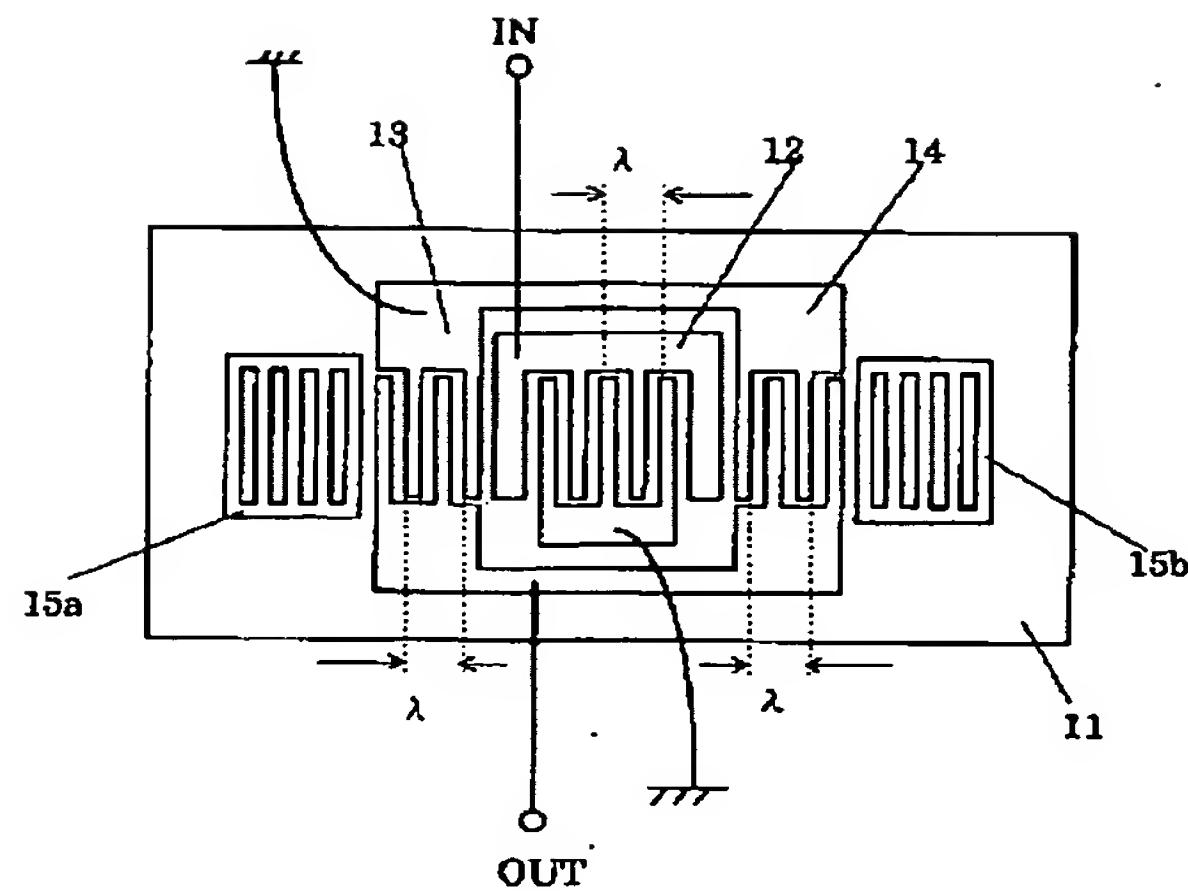


(a)

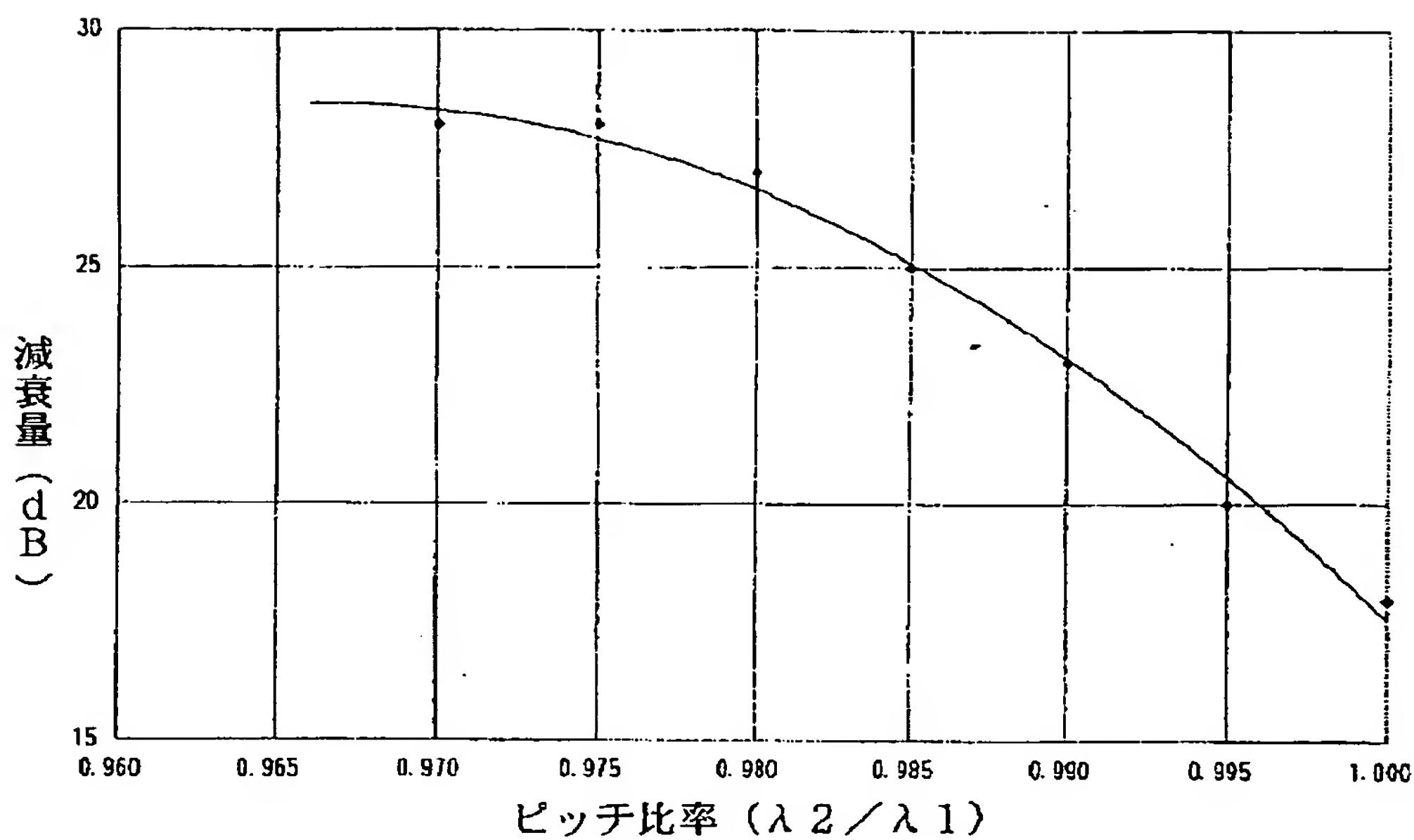
(b)

(c)

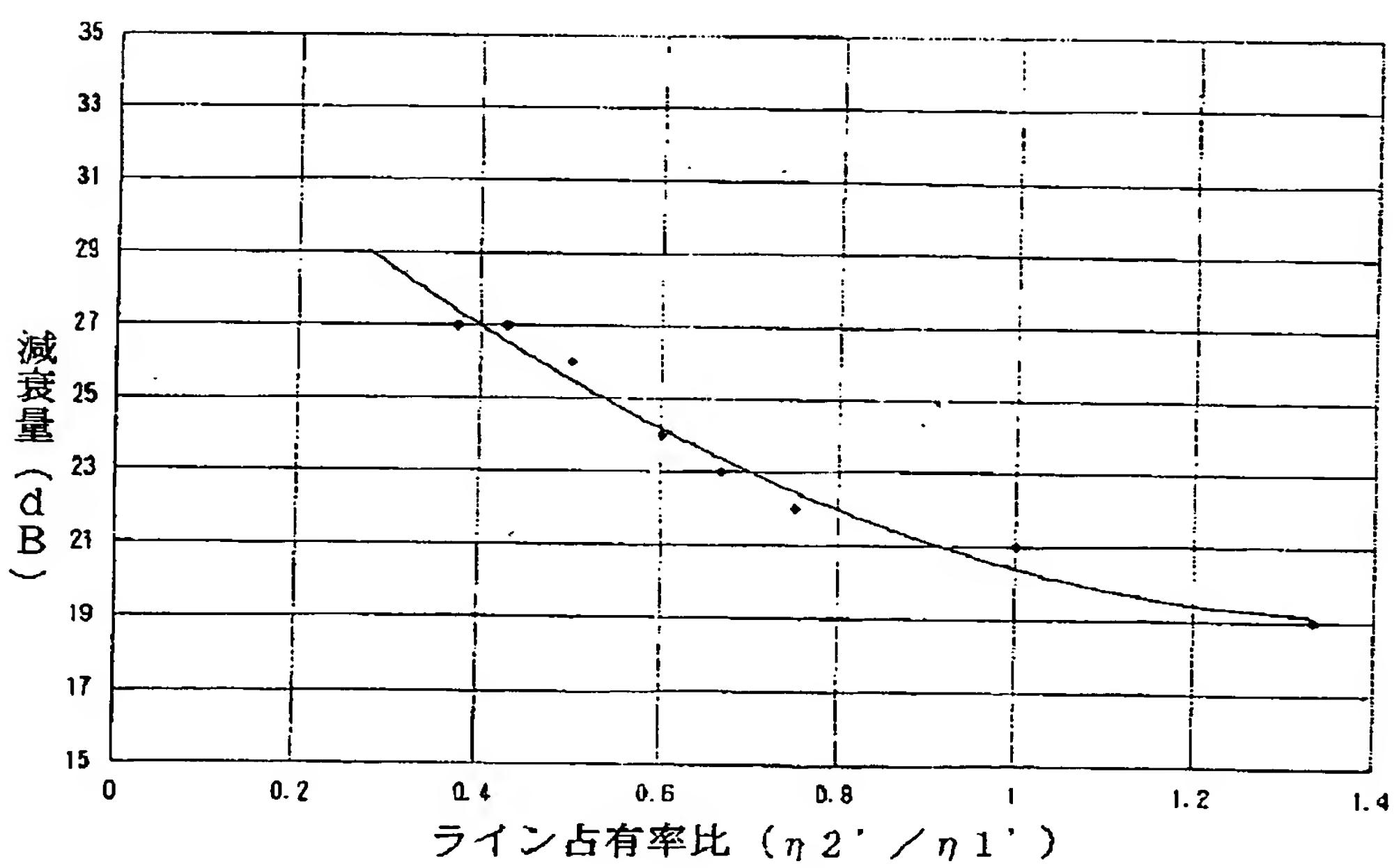
【図7】



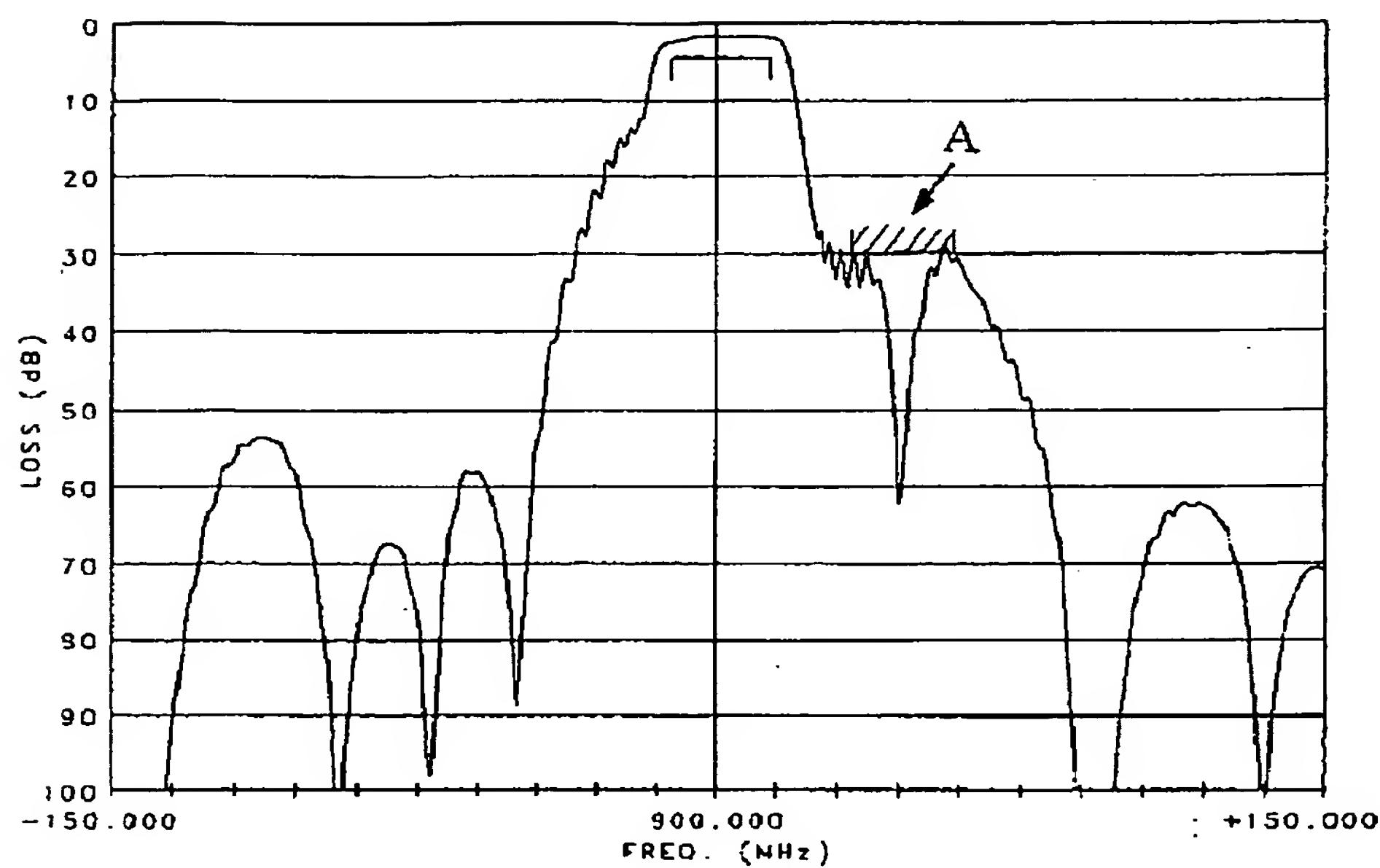
【図4】



【図5】



【図6】



【図8】

